CIMSS TC Intensity Satellite Consensus (SATCON)

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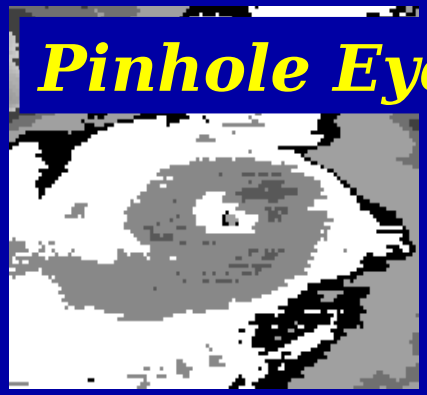
Motivation

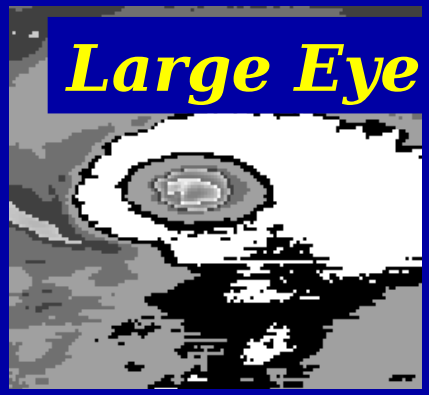
- Importance of getting current TC intensity right
  - Intensification trends
  - Predictor for statistical forecast models
  - Climatology (Basin Best Tracks)
  - Initial conditions for numerical models
- Estimates of TC intensity can vary by more than 40 knots
- Several objective TC intensity methods exist
- Goal is to assist forecasters in assessing current intensity by combining the best aspects of individual objective estimates into a single estimate

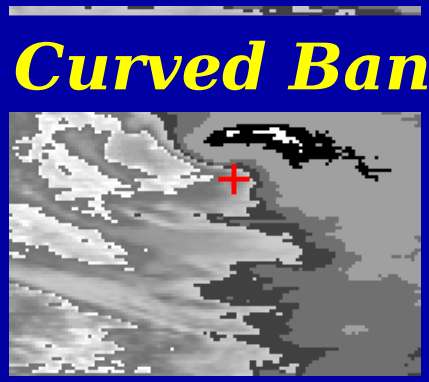
Members

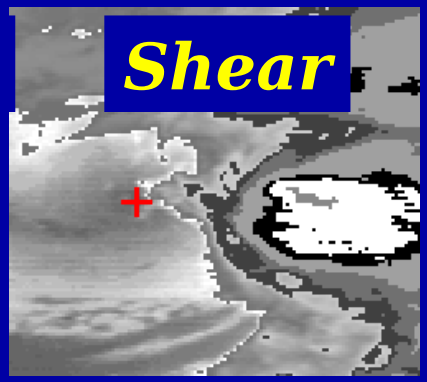
ADT

Uses IR imagery to assess eye temperature, curvature and cloud region temperature.









Members: ADT

Strengths

Time-averaging results in consistency
Temporal frequency - every 1/2 hour
Method based on the reliable Dvorak Technique
Global coverage with few gaps (eclipses)
Familiarity

Weaknesses

Sensitive to scene type identification
IR signature not strongly related to intensity
Time-averaging can miss rapid intensity changes

Members: CIMSS AMSU

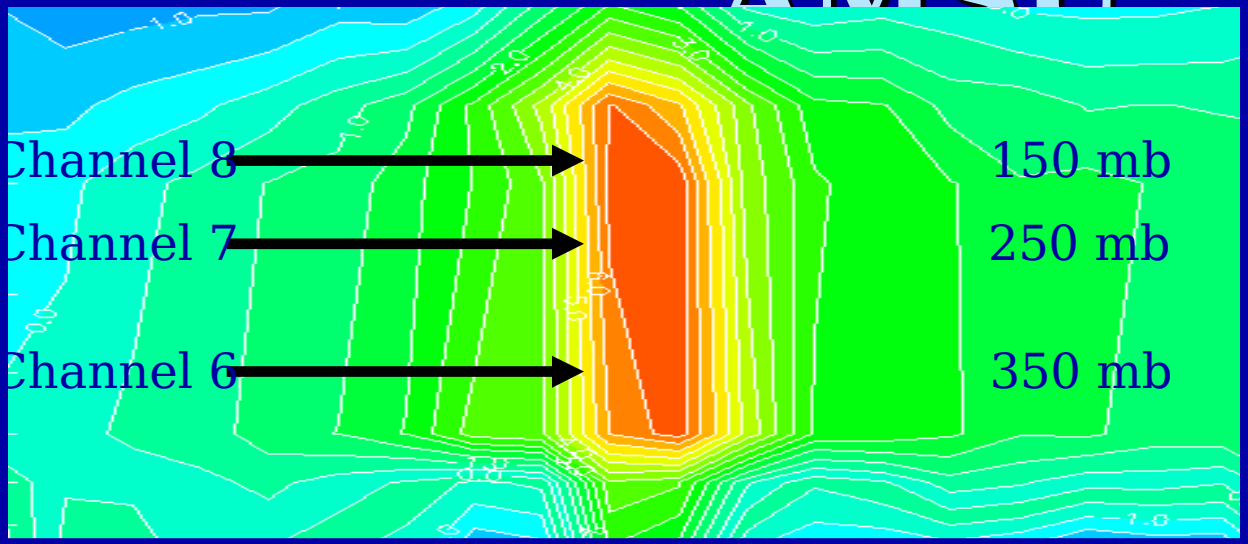
Microwave sounder which includes channels for measuring brightness temperatures (Tb) in the 550-150 mb layer.

AMSU-A (temperature) and AMSU-B (moisture) 1998-present
Resolution ~ 50 km at nadir to 100 km at the limb

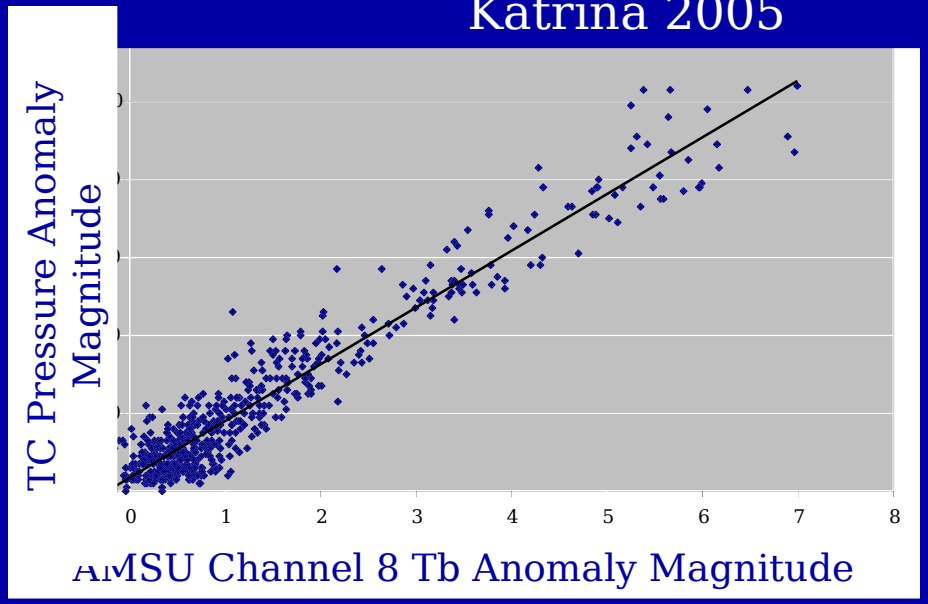
Multiple regression scheme using Tb anomaly magnitude from 3 AMSU-A channels (6-8) and 1 AMSU-B channel (16)

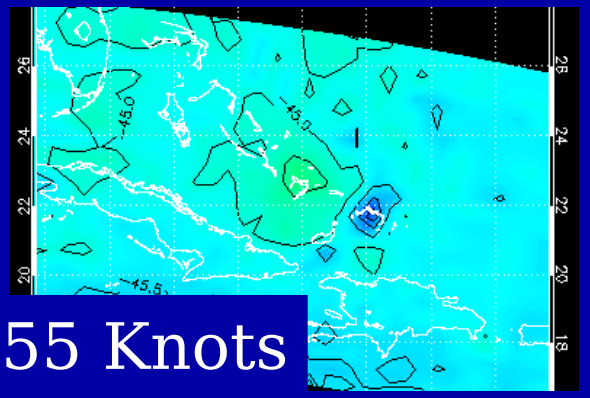
Corrections applied to account for sub-sampling, hydrometeor scattering and scan geometry

Members: CIMSS AMSU

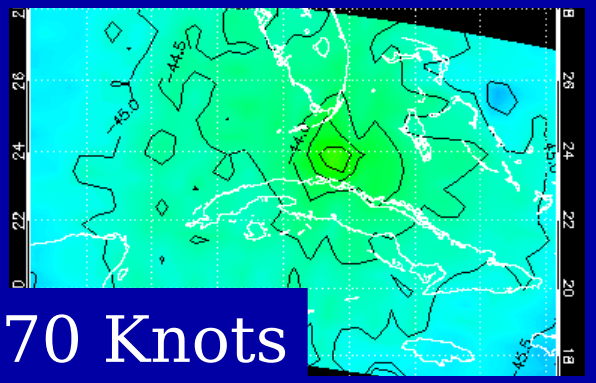


AMSU Tb Anomaly vertical cross section for Katrina 2005

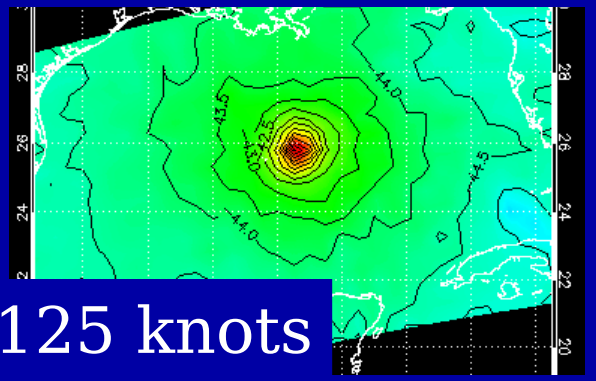




55 Knots



70 Knots



125 knots

Members: CIMSS AMSU

Strengths

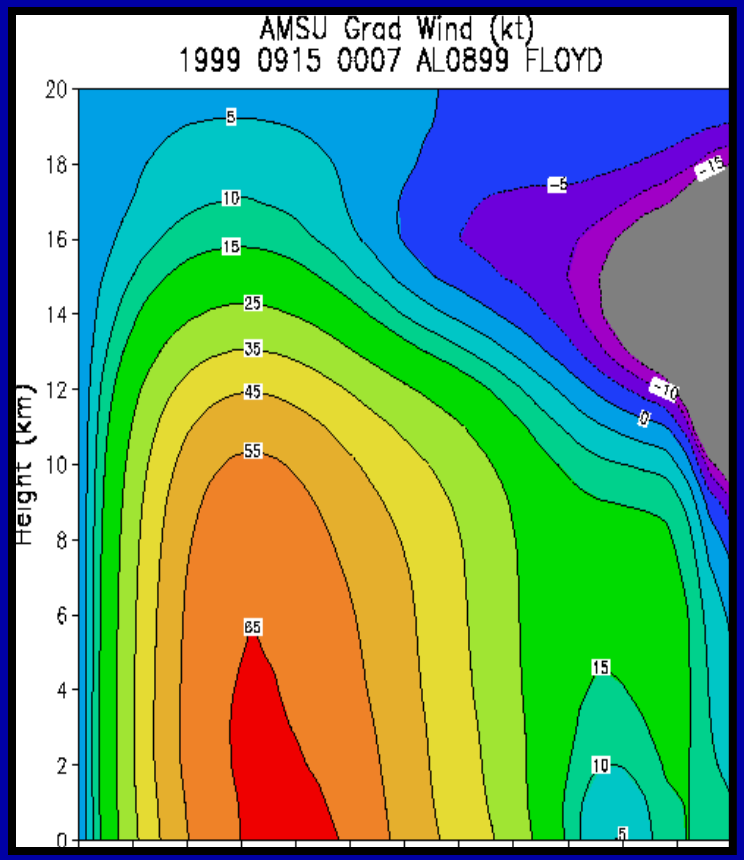
Tb Anomaly magnitude directly related to intensity
No dependence on previous estimate
TC-relative MSW training allows for motion component

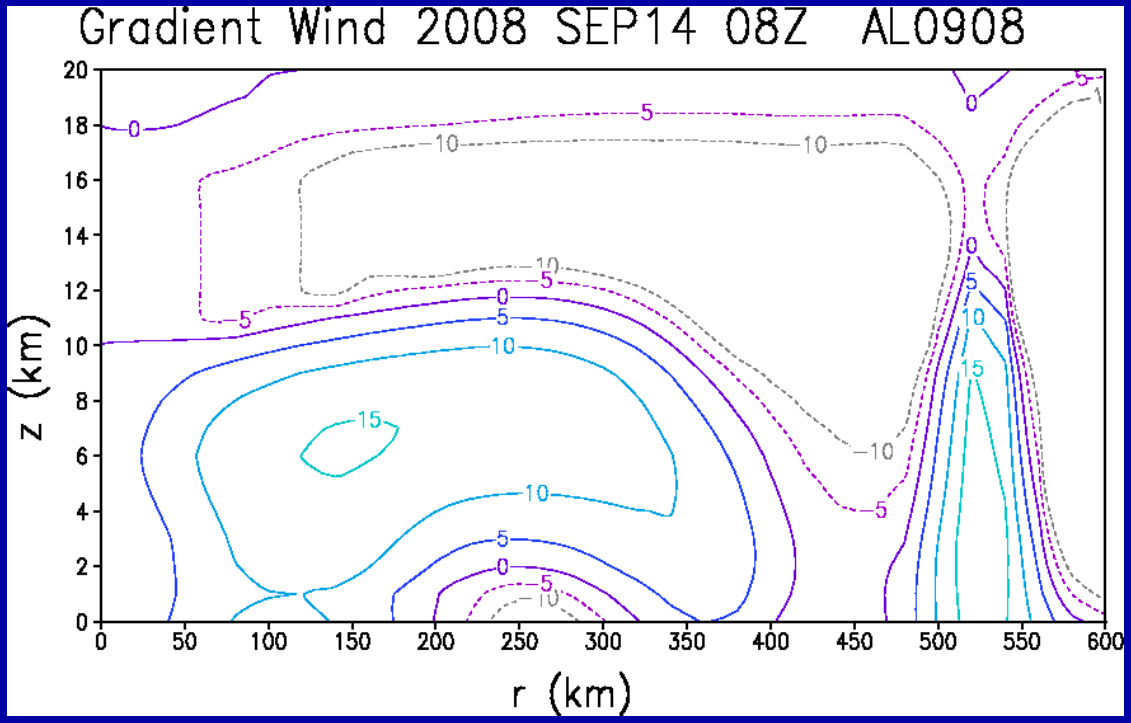
Weaknesses

Resolution requires sub-sampling corrections
Dependence on ancillary data (RMW, P_env)
Polar orbiter pass coverage

Members: CIRA AMSU

AMSU-A Tb are used to produce a statistical temperature retrieval at 23 pressure levels. Estimate of CLW is used to correct for attenuation due to hydrometers





Members: CIRA AMSU

Strengths

Temperature anomaly directly related to TC intensity
CLW useful in accounting for attenuation
Provides objective estimate of critical wind radii
Higher latitudes (Best Track training)

Weaknesses

CLW may not correct for all of the attenuation
Reliance on model data for boundary conditions
No sub-sampling correction for resolution

CIMSS SATCON

We can take the knowledge of these strengths and weaknesses and assign weights to each method based on situational performance

Then combine the estimates into a single SATellite CONsensus (SATCON) estimate

- ADT performs best in clear eye scenes
- CIMSS AMSU performs best for weaker storms and when eye is large for stronger storms
- CIRA AMSU performs best when eye is large and position of AMSU-A matches TC

Next Step: Information Sharing

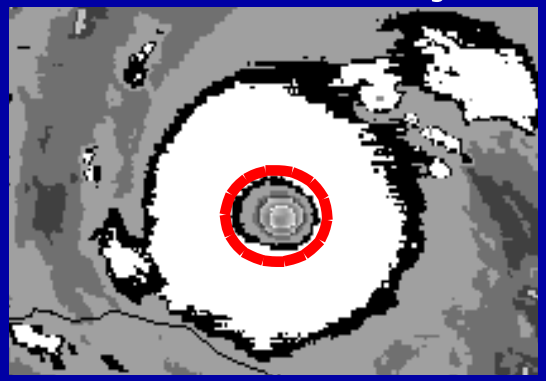
at relationships might exist between the parameter
member algorithms?

these parameters be shared across the algorithms
rove the individual members?

r all corrections are made re-define the weights
produce a weighted consensus of the corrected
nbers

Information Sharing: ADT to AMSU

Get Estimate of Eye Size



Compare to AMSU-A FOV resolution

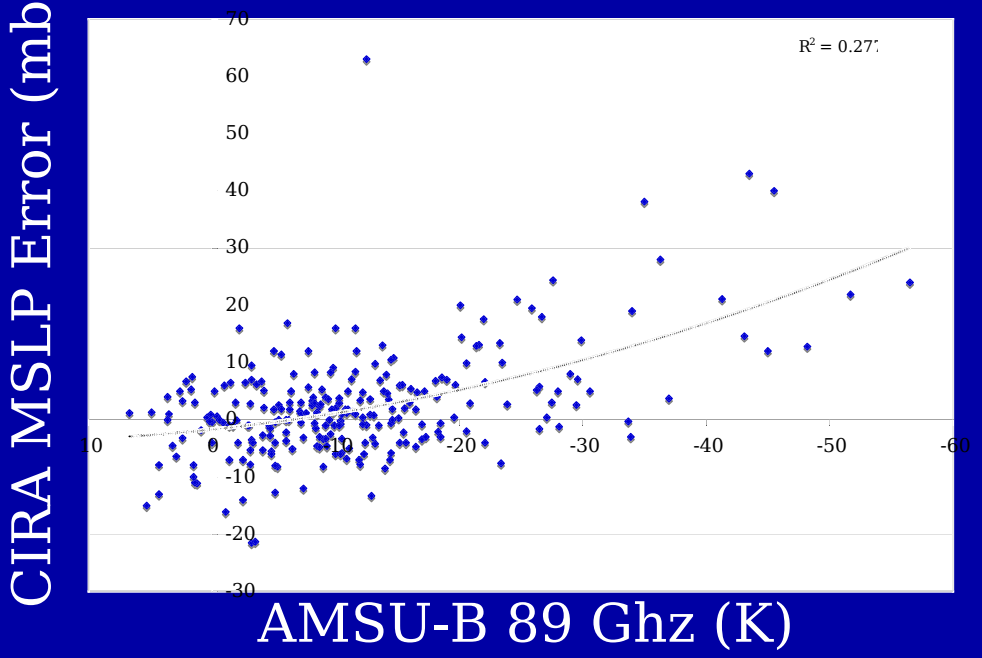
Adjust AMSU pressure if needed

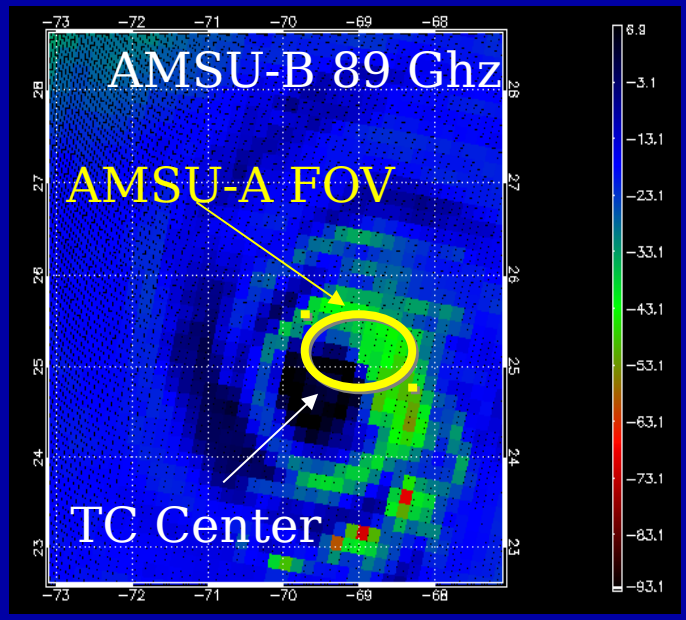
IR can be used to estimate eye size

CIMSS AMSU uses eye size information to correct resolution sub-sampling

Use RMW to adjust MSW?

Information Sharing: CIMSS to CIRA





tion bias used to correct CIMSS AMSU can be used for
A as well.

rong relationship exists between AMSU-B 89 Ghz signal
nvolved) within the AMSU-A FOV and CIRA estimate error f
n MSLP (shown) and MSW

Information Sharing

currently does not use any estimate of environmental press
messages used by CIMSS includes P_env

rm Motion Component

th ADT and CIRA AMSU developed using Best Track MSW c
component of the MSW imparted by storm motion is intrins
data set.

rm motions which deviate from the Best Track data averag
ut 11 knots) are not accounted for by these members.

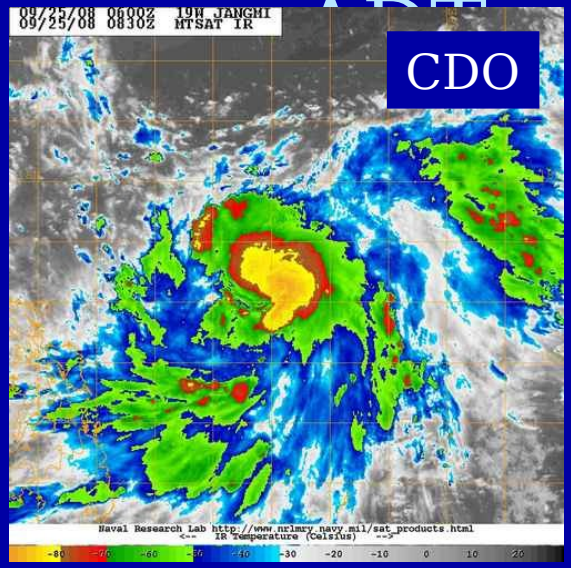
ply 50% of anomalous motion component (similar to Swerdt
e ADT and CIRA. Especially important for recurving storms
ng > 30 knots

SATCON: Weighting

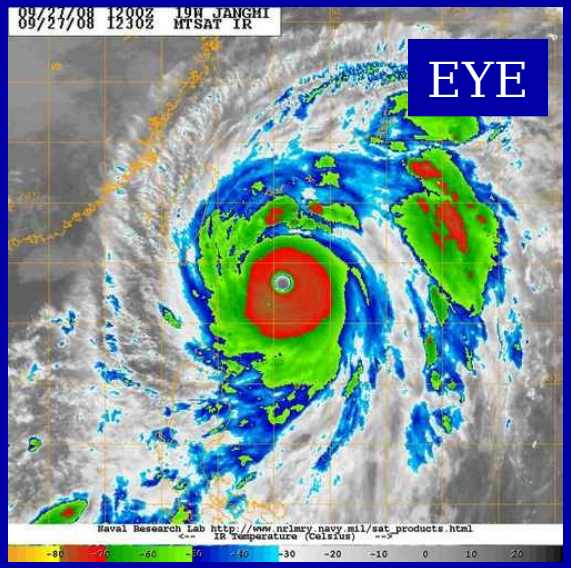
Weights are based on RMSE error for each member

- Separate weights for MSW and MSLP
- Weights are stratified by scene (ADT), scan geometry or level of estimated sub-sampling (AMSU)

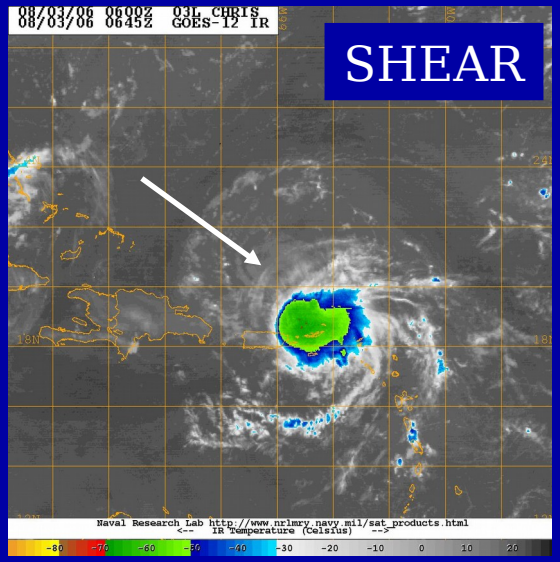
Member MSW Performance:



RMSE 14



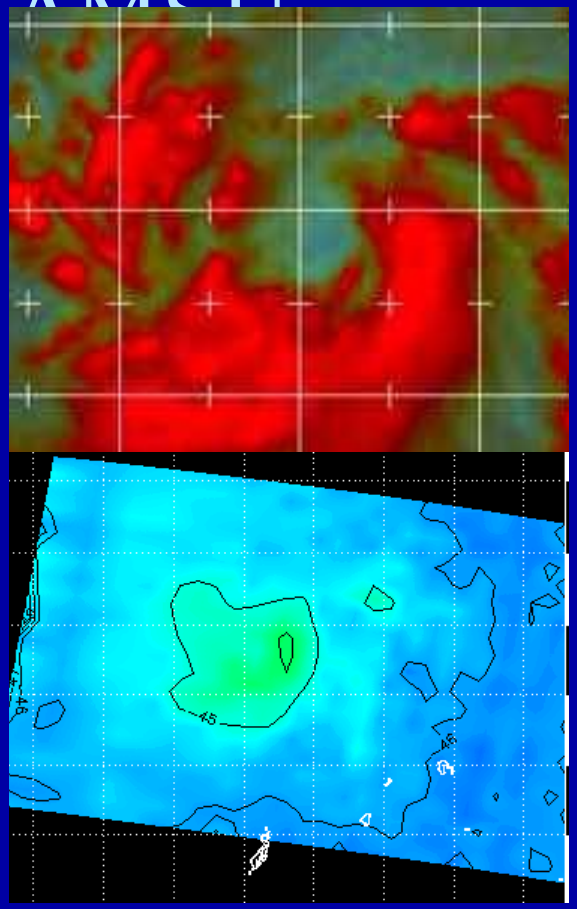
RMSE 12



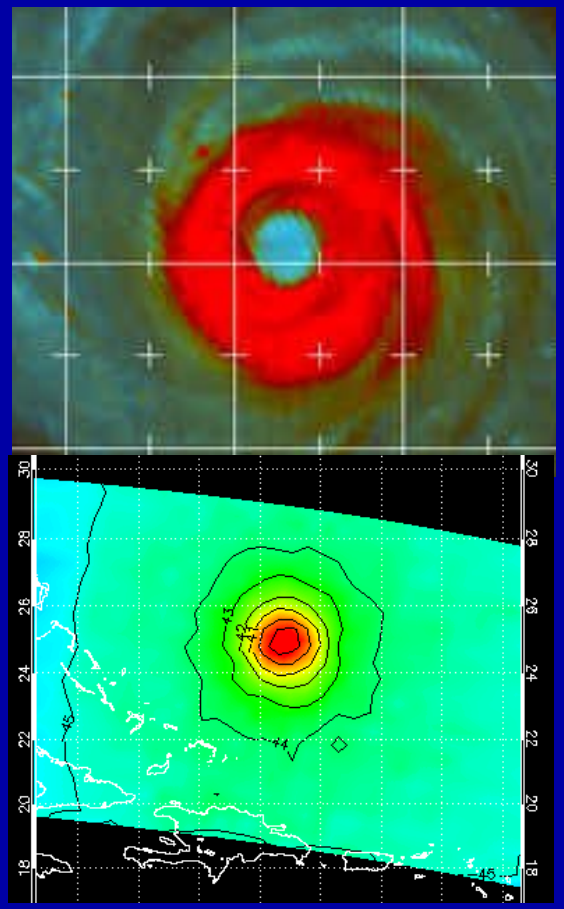
RMSE 18

SATCON: Weighting

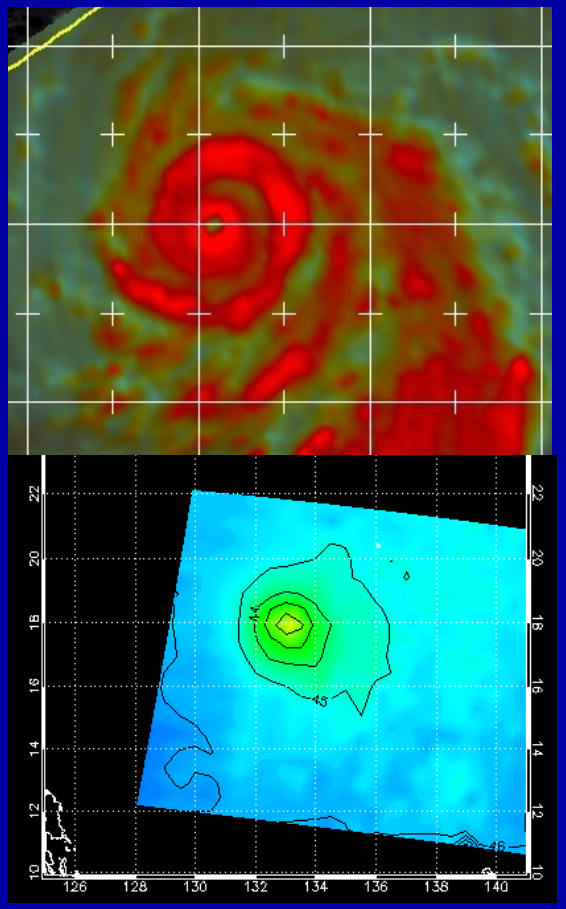
Member MSW Performance: CIMSS AMSU



RMSE 10



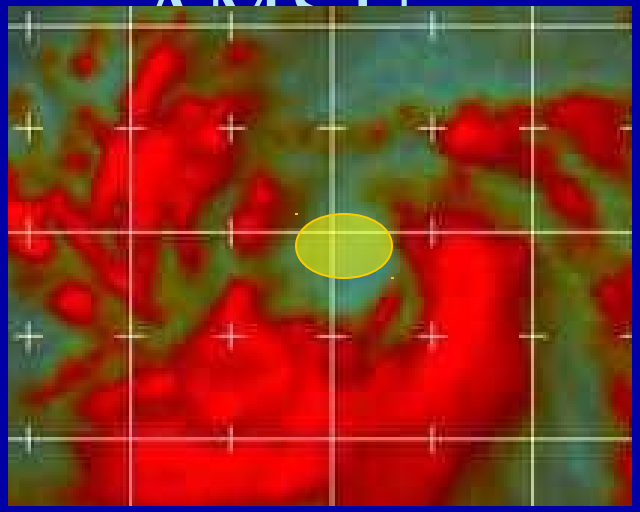
RMSE 12



RMSE 15

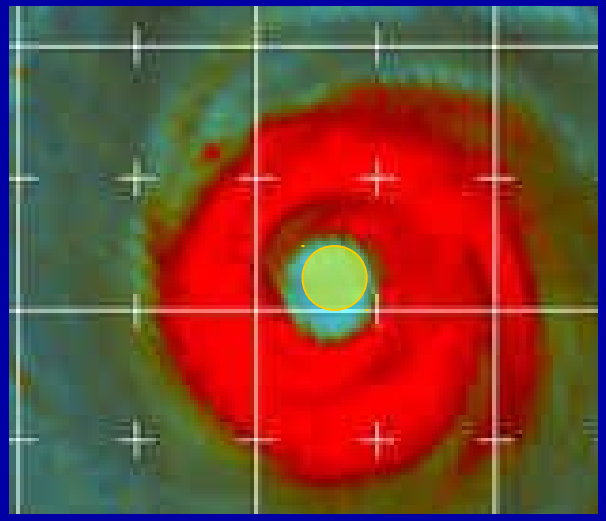
SATCON: Weighting

Member MSW Performance: CIRA AMSU



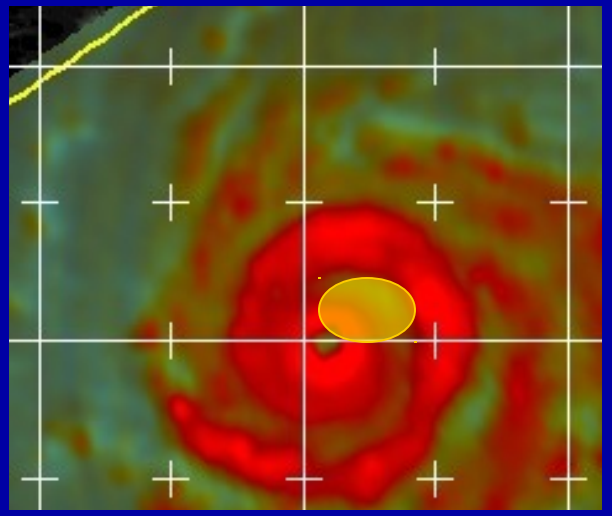
Weaker system, AMSU FOV near center

RMSE 12 knots



Strong system, AMSU FOV near center

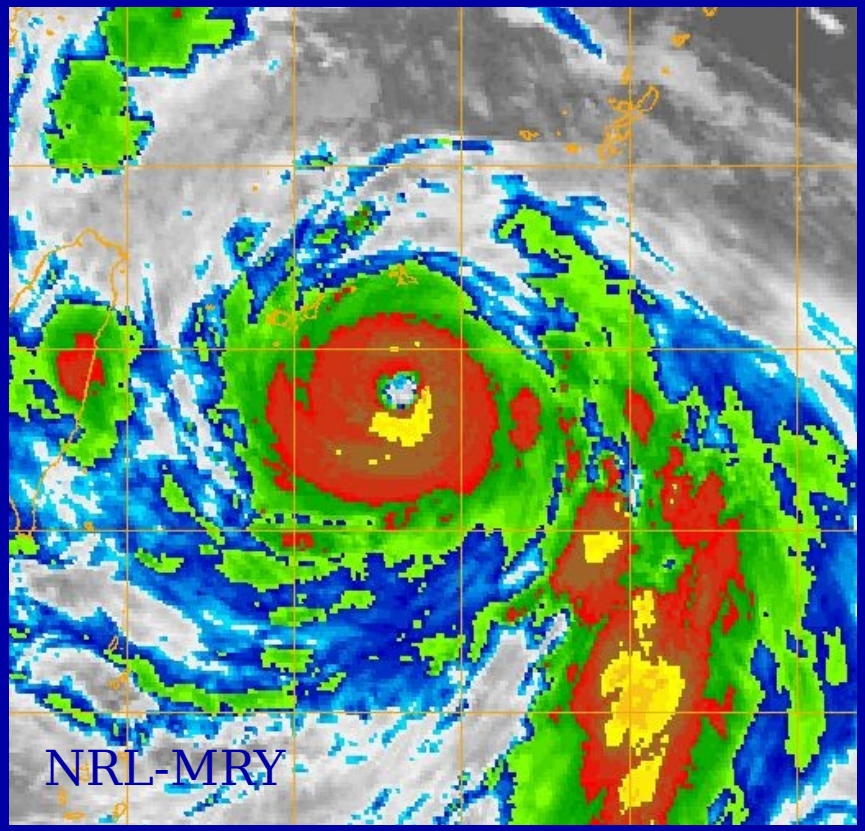
RMSE 15 knots



Strong system, AMSU FOV offset from center

RMSE 18 knots

Examples



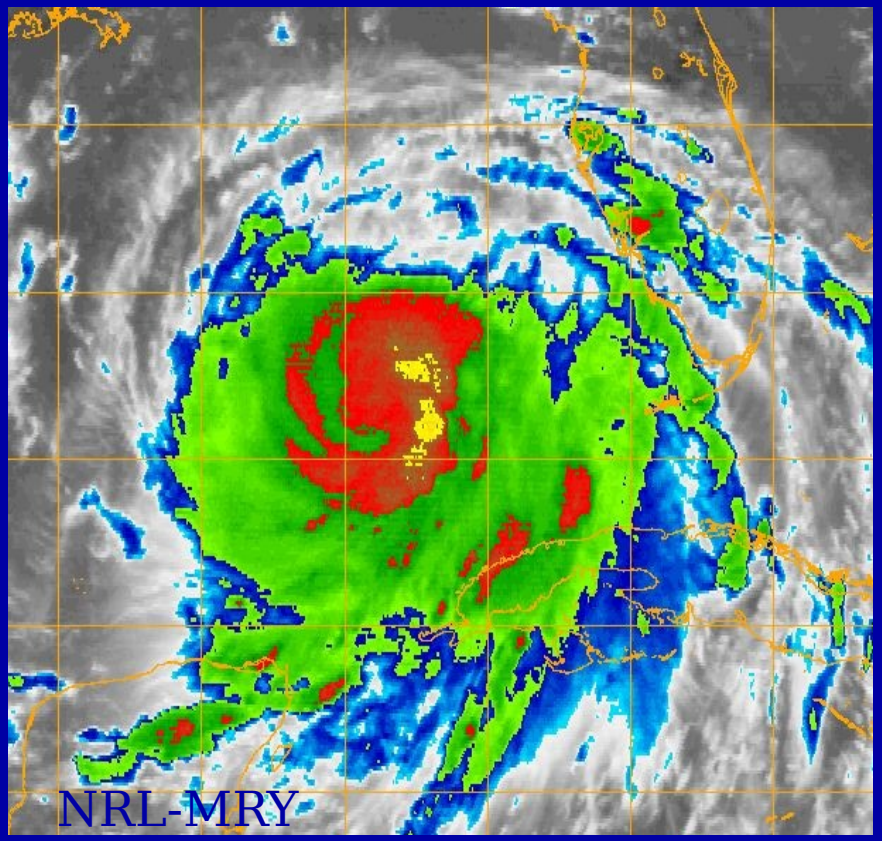
ADT determines scene is an eye scene

CIMSS AMSU near Nadir. Eye is large compared to AMSU resolution

CIRA is sub-sampled

ADT = 28 % CIMSS AMSU =47 % CIRA AMSU = 25 %

Examples



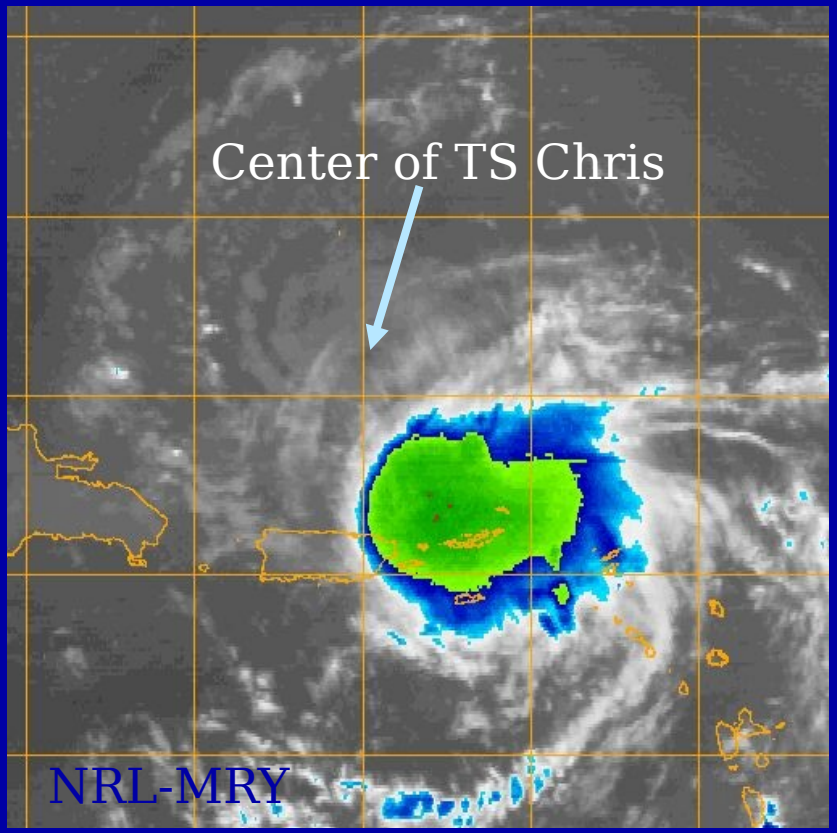
ADT determines scene is a CDO scene

CIMSS AMSU position near limb. Eye is small

CIRA AMSU position located near true TC center

ADT = 22 % CIMSS AMSU =34 % CIRA AMSU = 44 %

Examples



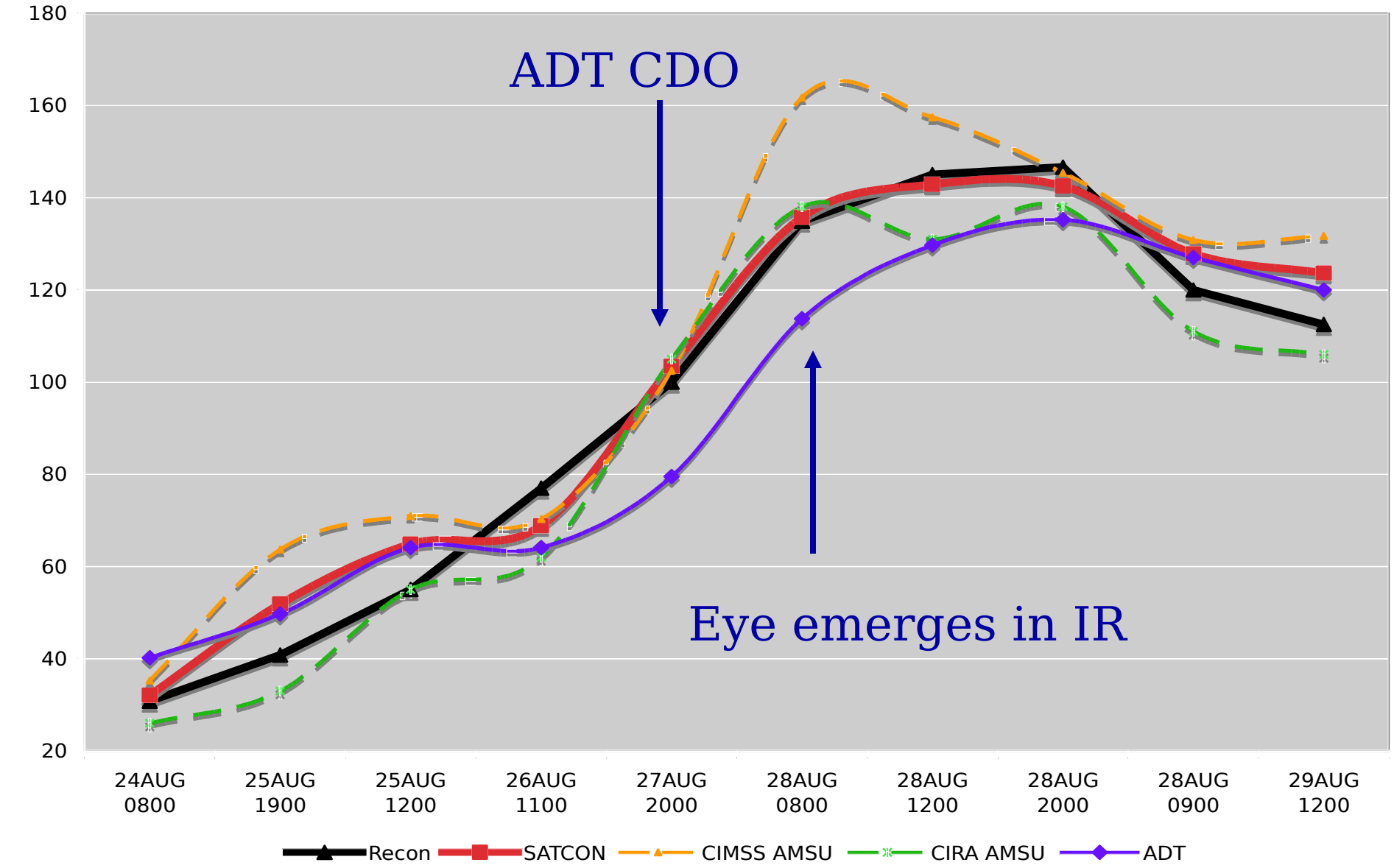
ADT determines scene is a SHEAR scene

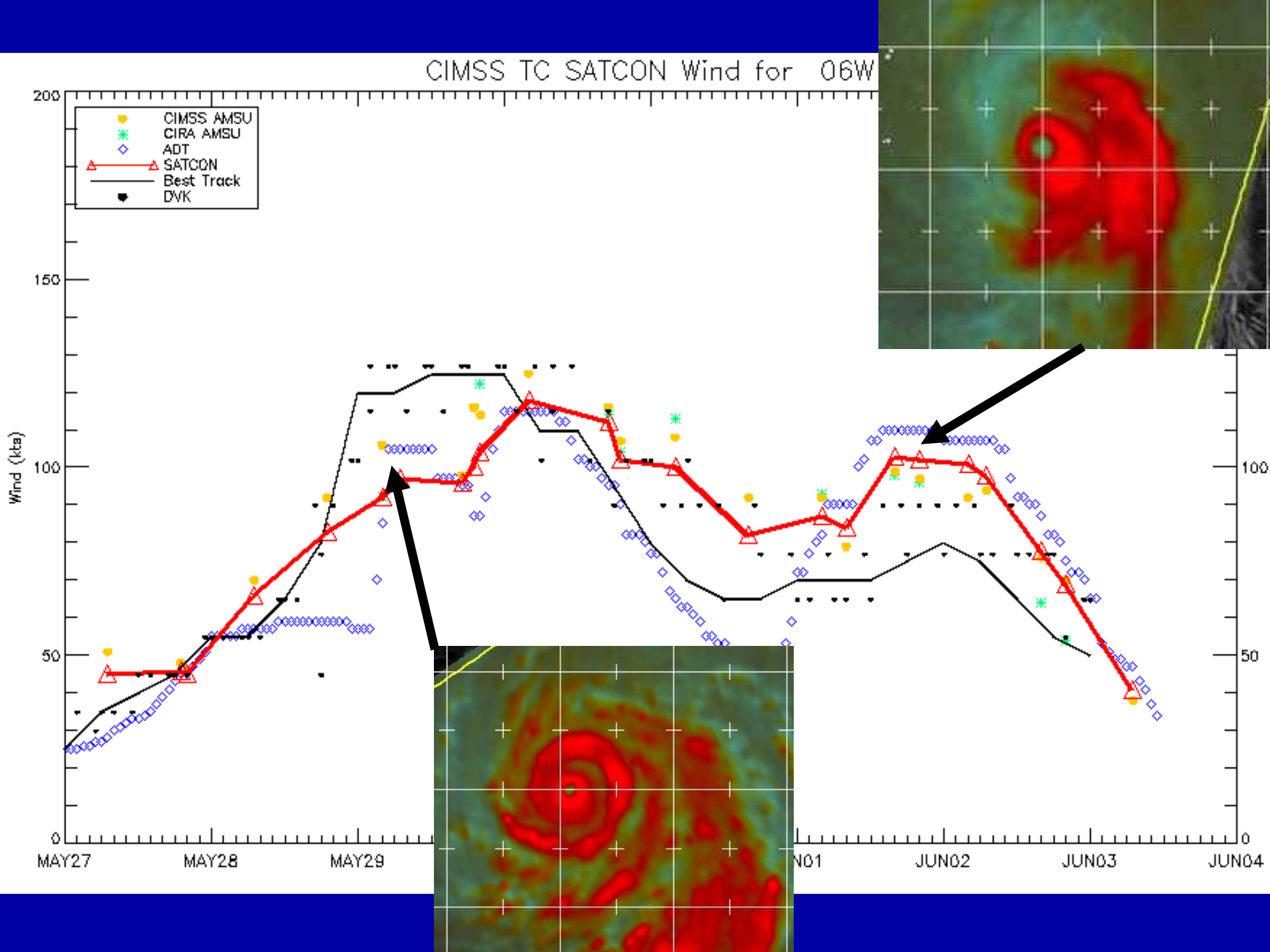
CIMSS AMSU indicates no sub-sampling present

CIRA AMSU: no sub-sampling due to position offset

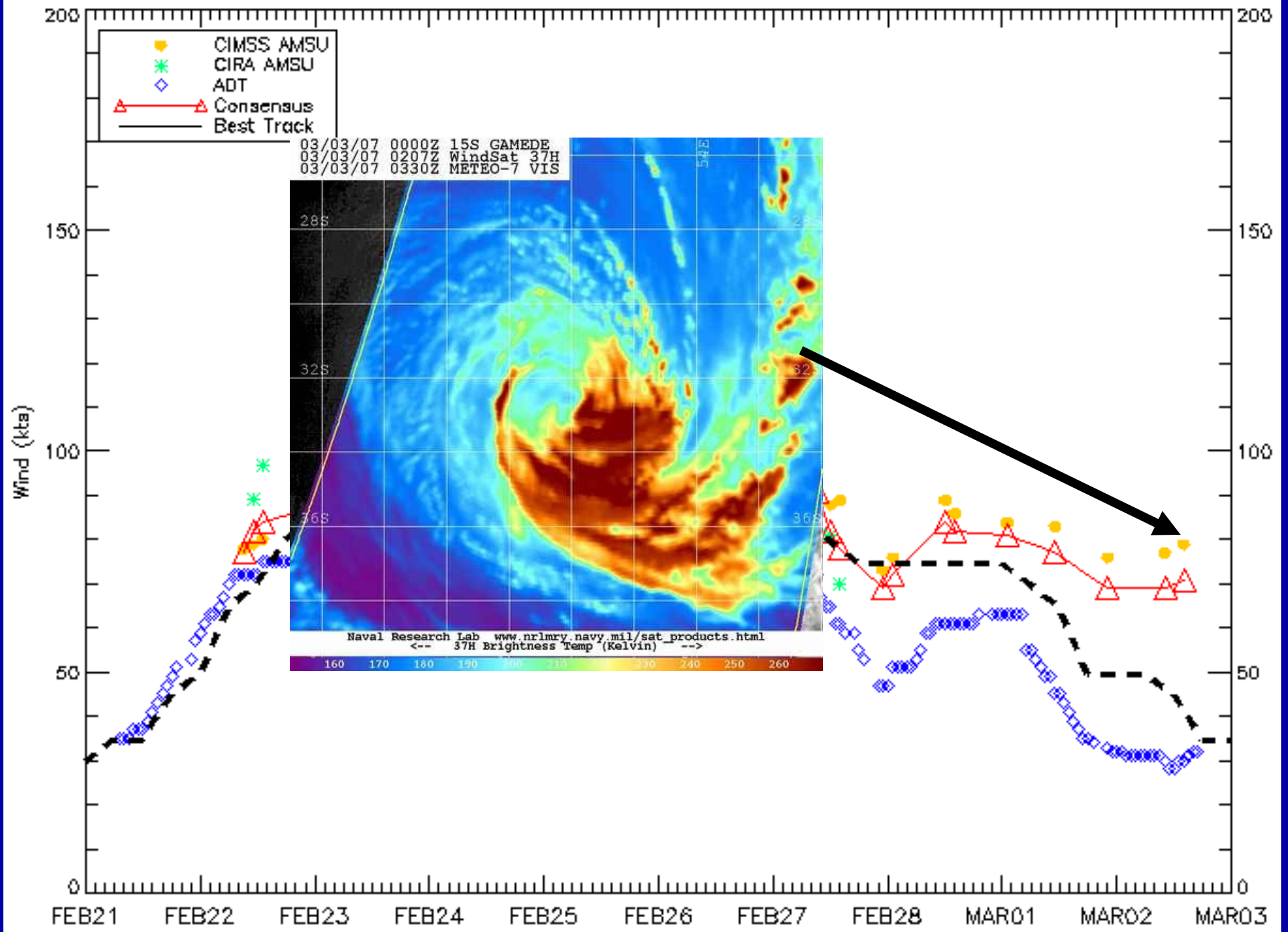
ADT = 18 % CIMSS AMSU =41 % CIRA AMSU = 41 %

Examples: Katrina 2005




CIMSS TC SATCON Wind for 06W
CIMSS AMSU
CIRA AMSU
ADT
SATCON
Best Track
DVK
Wind (kts)
200
150
100
50
0
MAY27
MAY28
MAY29
JUN01
JUN02
JUN03
JUN04

CIMSS TC SATCON Wind for 15S



1999-2006 Stats (MSW)

	CIMSS AMSU	CIMSS ADT	CIRA AMSU	SATCON
BIAS	-3.9	- 4.9	-7.3	**-2.0**
AVG ERROR	8.9	12.3	11.1	**7.6**
RMSE	11.2	16.1	15.0	**9.6**
N	258	258	258	**258**

pendent sample. Values in knots. Validation is best track msw coincident with craft recon +/- 3 hours from estimate time. A - bias = method was too weak.

1999-2006 Stats Compare to Simple

	SATCON MSLP	SIMPLE MSLP	SATCON MSW	SIMPLE MSW
BIAS	0.0	-2.2	-2.0	- 4.7
AVG ERROR	4.7	5.2	7.6	8.7
RMSE	6.7	7.8	9.6	11.1
N	258	258	258	258

ependent sample. MSW validation in knots. MSLP validation in millibars.
bias = method was too weak. SIMPLE is simple average of the 3 members

1999-2006 Compare to Dvorak

	SATCON MSLP	Dvorak MSLP	SATCON MSW	Dvorak MSW
BIAS	0.4	-2.6	0.8	-1.6
AVG ERROR	4.9	7.5	7.3	7.9
RMSE	7.0	10.1	9.3	10.3
N	270	270	270	270

MSW validation in knots vs. Best Track. MSLP validation in millibars vs. recon.
eg. bias = method was too weak. Dvorak is average of TAFB and SAB estimates

2007-2008 Stats (MSW)

	CIMSS AMSU	CIMSS ADT	CIRA AMSU	SATCON
BIAS	- 2.6	- 4.4	-10.3	**-3.3**
AVG ERROR	9.2	9.9	15.0	**8.2**
RMSE	12.0	12.7	19.1	**10.1**
N	144	144	144	**144**

ependent sample. Values in knots. Validation is best track msw coincident with
craft recon +/- 3 hours from estimate time. - bias = method was too weak.

2007-2008 Compare to Dvorak

	SATCON MSLP	Dvorak MSLP	SATCON MSW	Dvorak MSW
BIAS	-0.3	-1.8	-3.3	- 3.1
AVG ERROR	4.8	6.2	8.2	7.3
RMSE	6.3	8.4	10.1	9.4
N	144	144	144	144

dependent validation. MSW validation in knots. MSLP validation in millibars.
ias = method was too weak. Dvorak is average of SAB and TAFB

Future Work

- Add error bars for estimate confidence
- Continue cross-platform information sharing
- Add additional TC intensity methods (SSMI / TRMM ?)
- ADT-MW
- Interactive Web Interface
- JTWC will evaluate during 2009 season

References

K. and C. Velden 2003: Satellite-Based Tropical Cyclone Intensity Estimation Using the LM Series Advanced Microwave Sounding Unit (AMSU). *Monthly Weather Review 131, Issue 4 (April 2003) pp. 687–697*

J. and M. Demaria, 2004: Evaluation of Advanced Microwave Sounding Unit Tropical-Cy and Size Estimation Algorithms. *Journal of Applied Meteorology 43, Issue 2 (February 2004) pp. 282–296*

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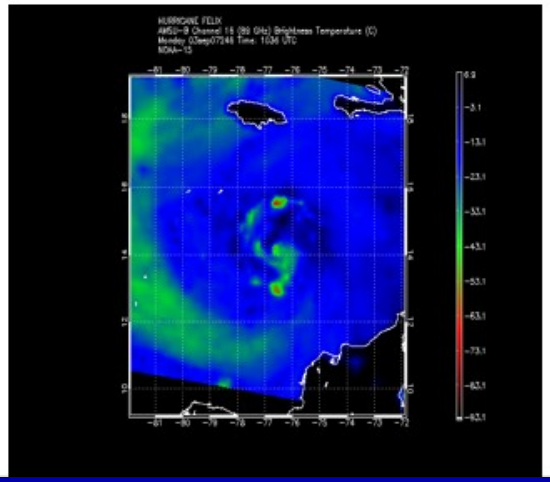
T. 2007: The Advanced Dvorak Technique: Continued Development of an Objective Schem Tropical Cyclone Intensity Using Geostationary Infrared Satellite Imagery. *Wea. and For 22, Issue 2 (April 2007) pp. 287–298*

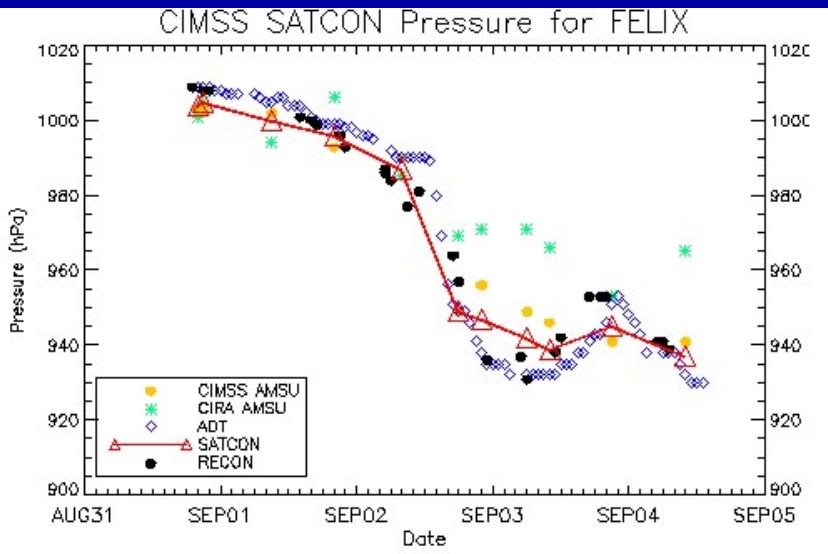
. 2006: The Dvorak Tropical Cyclone Intensity Estimation Technique: A Satellite-Based M Endured for over 30 Years. *Bulletin of the American Meteorological Society Volume 87, ber 2006) pp. 1195–1210*

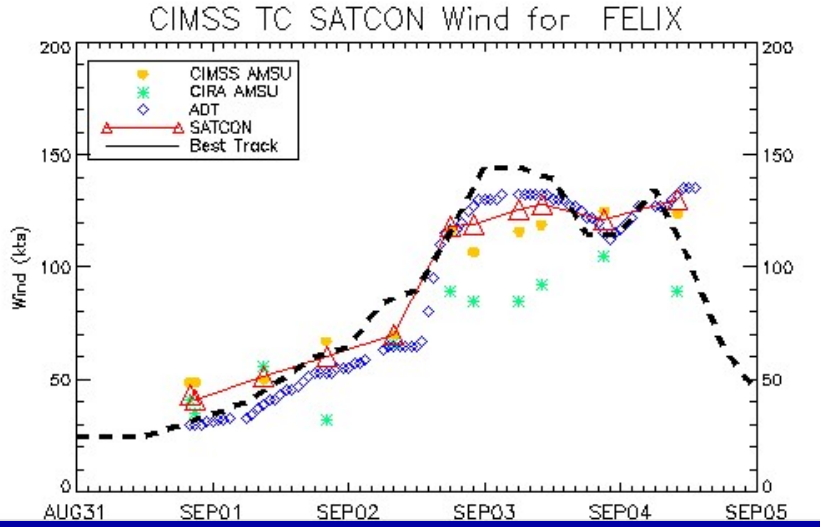
SATCON HOMEPAGE

CURRENT ESTIMATE
Date (yyyymmddhh): 2007090413
SATCON (3mem): MSLP = 937 hPa MSW = 130 kt
ADT: 932 hPa 132 kt Scene: EYE
CIMSS AMSU: 941 hPa 124 kt Bias Corr: -12 (IR)
CIRA AMSU: 965 hPa 89 kt clw: 1.28

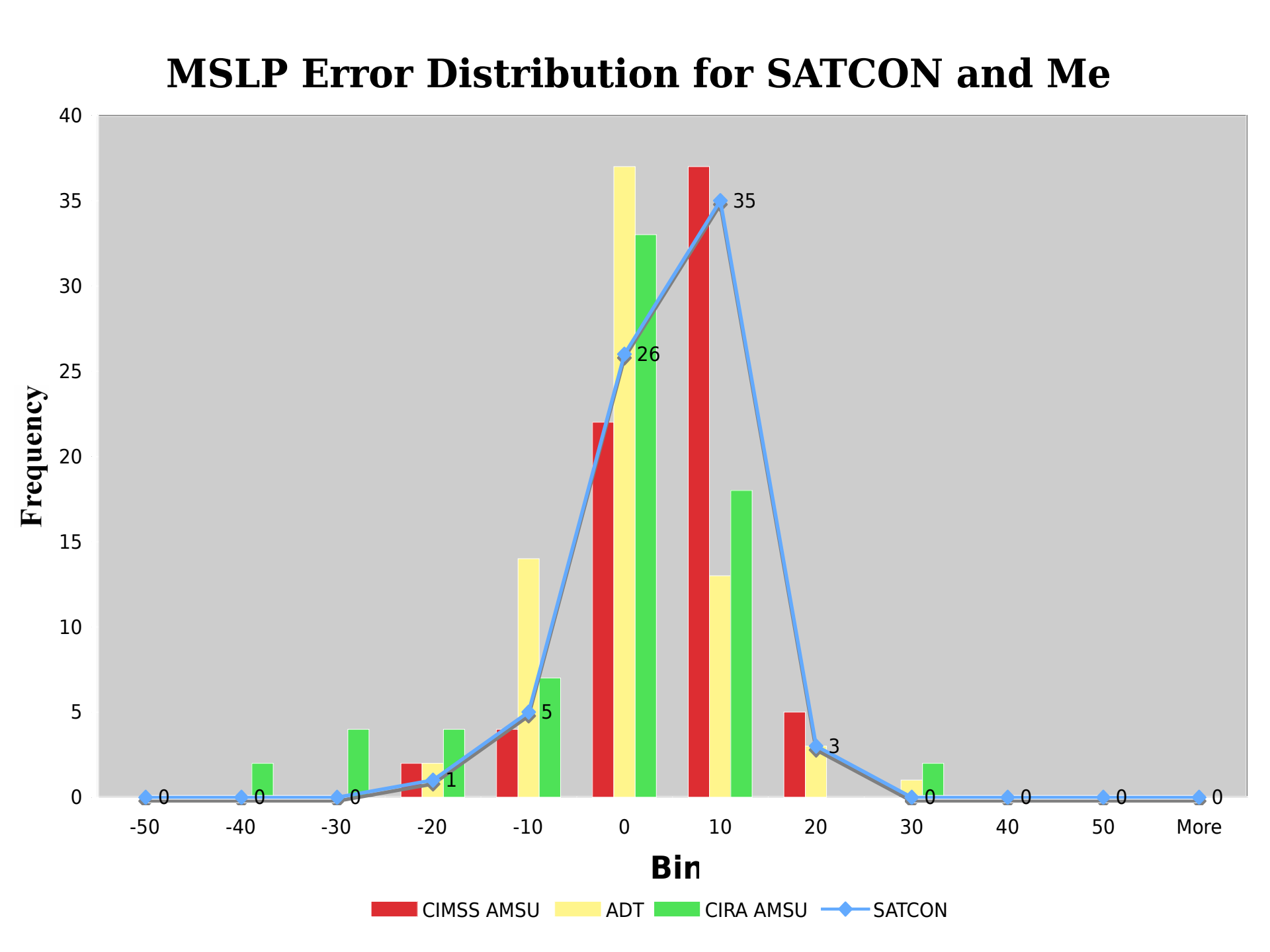
Date	SATCON		CIMSS_AMSU		ADT		CIRA_AMSU	
	MSW	MSLP	MSW	MSLP	MSW	MSLP	MSW	MSLP
090410	130	937	124	941	132	932	89	965
090321	121	945	125	941	115	951	105	953
090310	128	939	119	946	132	932	92	966
090306	126	942	116	949	132	932	85	971
090222	119	947	107	956	127	938	85	971
090218	118	949	116	949	117	949	89	969
090208	70	987	70	990	65	990	66	985
090120	60	996	67	993	53	999	32	1006
090109	51	1000	50	1002	39	1005	56	994





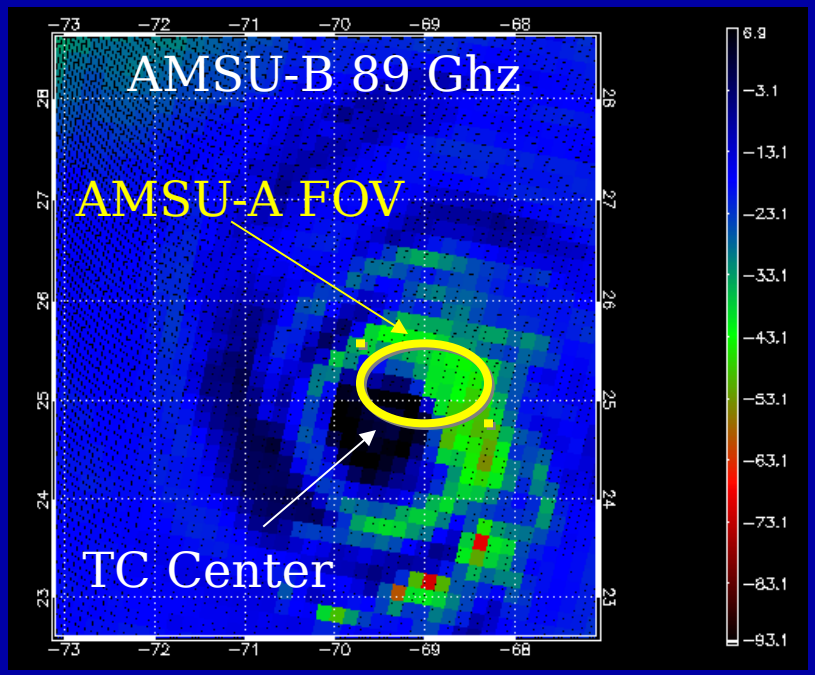


http://cimss.ssec.wisc.edu/tropic2/real-time/satcon


MSLP Error Distribution for SATCON and Me
Frequency
40
35
30
25
20
15
10
5
0
0
0
0
1
5
26
35
3
0
0
0
0
-50
-40
-30
-20
-10
0
10
20
30
40
50
More
Bin
CIMSS AMSU
ADT
CIRA AMSU
SATCON

AMSU Sub-sampling Corrections

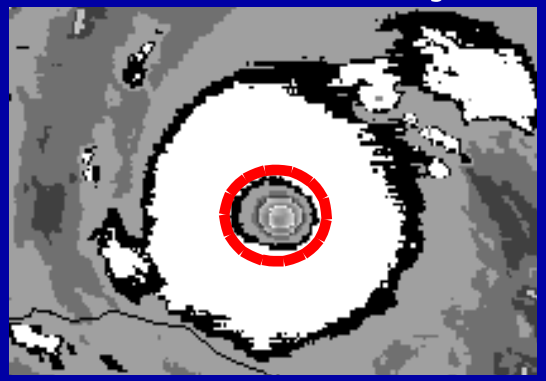
Correcting for position

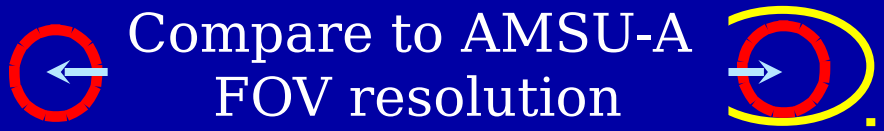


ortion of TC eyewall is within the MSU-A FOV indicating the AMSU-A xel location is offset from true TC enter. Find AMSU-B center-weighted onvolved) Tb. Used as regression erm.

Correcting for resolution

Get Estimate of Eye Size





Adjust AMSU pressure if needed

Members: CIRA AMSU

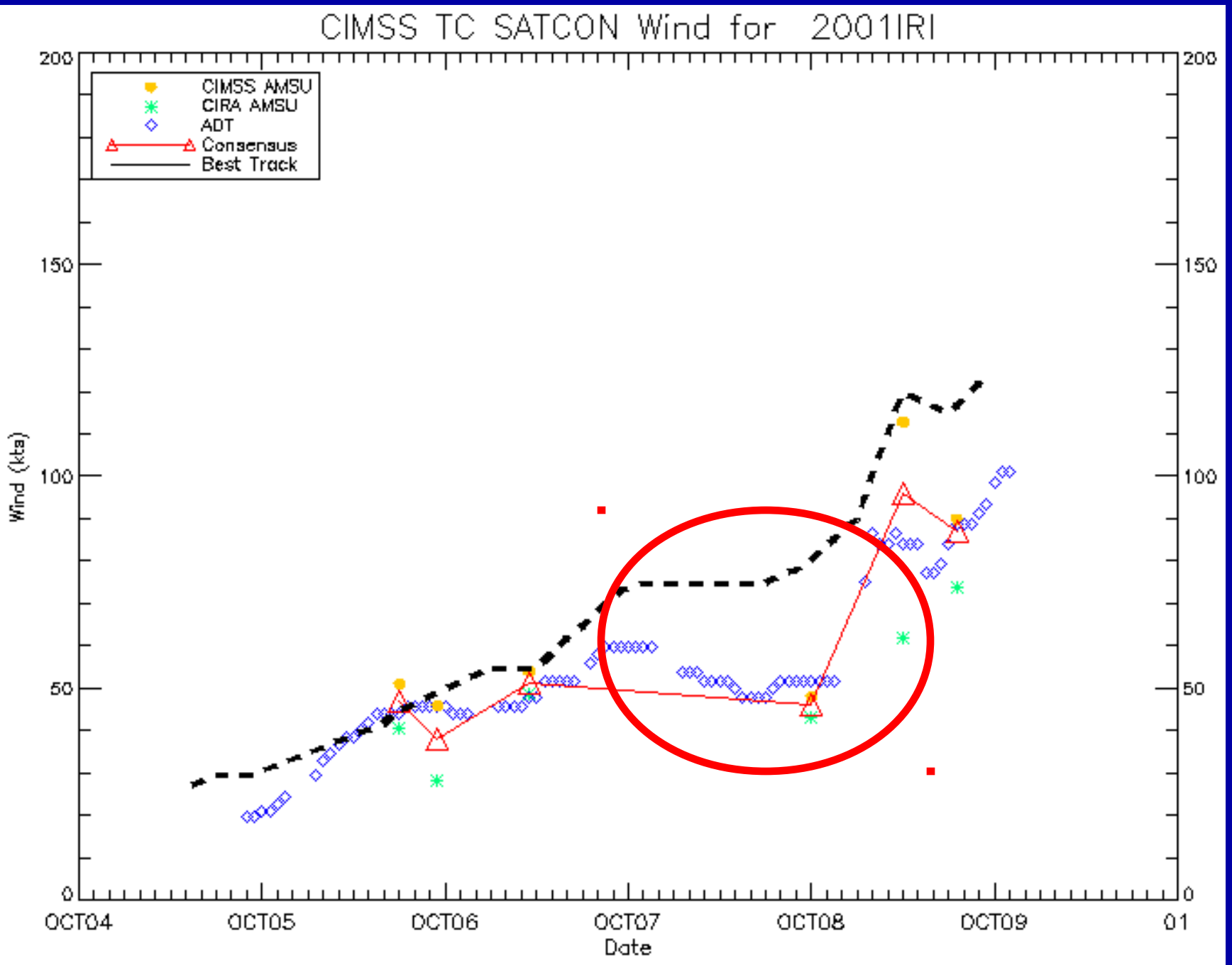
CIRA AMSU TC intensity predictors

MSW

Tangential wind at height of 5 km
Maximum temperature anomaly
Average CLW within 100 km radius
Percent of CLW > 0.5 mm within 300 km
RMW at height of 3 km
AMSU-A FOV resolution

MSLP

Pressure anomaly estimated from 600 km radius to center


CIMSS TC SATCON Wind for 2001IRI
CIMSS AMSU
CIRA AMSU
ADT
Consensus
Best Track
Wind (kts)
200
150
100
50
0
OCT04
OCT05
OCT06
OCT07
OCT08
OCT09
01
Date

1999-2006 Stats (Pressure)

	CIMSS AMSU	CIMSS ADT	CIRA AMSU	SATCON
BIAS	-0.3	-3.9	-2.9	**0.0**
AVG ERROR	5.7	9.5	6.7	**4.7**
RMSE	7.5	13.3	10.3	**6.7**
N	258	258	258	**258**

pendent sample. Values in millibars. Validation is aircraft recon (buoys) pressu
- 3 hours from estimate time - bias = method was too weak.